Report for 2001GU1321B: Investigation of the Use of Locally Available Materials for Slow Sand Filtration In Kosrae State, Federated States of Micronesia

- Water Resources Research Institute Reports:
  - Khosrowpanah S., L. Heitz, & C. Beausoliel, The Application of Slow Sand Filtration Technology for Kosrae State, FSM: A Pilot Project, University of Guam/WERI, Technical Report No. 91a, May 2001.
- Conference Proceedings:
  - Khosrowpanah S., & L. Heitz, The application of Slow Sand Filtration Technology for Kosrae State, the Federated States of Micronesia: A Pilot Project, in Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.

Report Follows:

PROJECT SYNOPSIS REPORT

Title: Investigation of the Use of Locally Available Materials for Slow Sand Filtration In Kosrae State, Federated States of Micronesia

Problems and Research Objectives:

The lack of clean drinking water is a significant problem for residents of the high, volcanic islands of the Federated States of Micronesia (FSM). Residents of Kosrae State, the easternmost member of the FSM, are highly reliant on surface water resources. These waters however, are not treated, due to a lack of funding for conventional treatment methods. Consequently, untreated water is piped directly into people's homes bearing with it significant sediment and contamination. Study by the Hawaii Department of Health (1991) indicates that Kosrae has one of the highest incidences of water related diseases in the world. In order to reduce the incidence rate of water borne illnesses, water treatment is necessary. The treatment technology must be economical to build, and simple to operate and maintain given the adverse economic and environmental conditions of this remote island. For these reasons, slow sand filtration was selected as a potential water treatment technology. The objectives of this study were: 1) modify the existing pilot plant to gain better flow control to the test cylinders, 2) measure the level of turbidity and coliform removal, under various hydraulic loading rates, 3) evaluate different local sand size distributions, and 4) determine the economic and technical feasibility of using the local sources as opposed to previously tested commercially available sources.

Methodology:

This project was divided into four phases as described below:

Phase I. Modifications to Existing Pilot Plant. We used the existing pilot plant that was constructed for the previous study. This plant consists of four test cylinders that were constructed near the Tofol stream in Kosrae. Each plant includes a PVC pipe 13 feet long, 12-inch diameter with 5.5 feet of sand media sitting on 1.8 feet of gravel bed. To measure the head loss across the cylinder, each cylinder is equipped with three piezometers, sampling taps, and an outflow weir that prevents the creation of negative pressure across the filter media. For this study we used only two of the test cylinders. Two modifications were done with the pilot plant. One was using a variable volume flow rate peristaltic pumps, regulating the inflow to the each cylinder at approximately 230 ml/min. The other modification was installing a submersible sump pump that supplies water from the source stream next to the plant to an on-site storage tank. The solids were held in suspension using an aquarium pump circulating air through the tank. The peristaltic pumps fed directly from the tank to the test cylinders. These two changes guaranteed that a continuous flow from the stream with a constant rate was input to the test cylinders at all times.

The two filters that were used had a locally manufactured sand material that has been prepared according to typical SSF specifications.

Phase II. Testing the loading rate and different local sand size distributions
Originally we had planned to run the pilot plants with four different hydraulic loading rates such as 2.6, 3.9, 5.2, and 7.8 ml/sec. However, after our preliminary results, we decided to use only one loading rate which was 2.6 ml/sec. This decision was based on the level of turbidity of the inflow to the filters.

To determine the best sand size distribution for the filters that could give us a longer filter run between scrapping, we used local materials with Uniformity Coefficient (UC = d_{60}/d_{10}) of 2 and 2.2. The Uniformity Coefficient is a reflection of the degree of variation in particle sizes. A lower UC indicates more uniformity in particle sizes, which generally results in a higher porosity. A higher UC indicates greater variation in particle sizes and usually indicates reduced porosity.

Phase III. Monitoring and testing The testing, that was started in February and was continued until end of July of this year, included: 1) daily flow measurement to the filters to be sure that constant flow is being delivered to the filters, 2) daily inflow/outflow turbidity measurement to determine the filter's turbidity removal rate, 3) daily head loss measurement across the filter bed to determine the scrapping time for the filters, 4) daily inflow/outflow temperature measurement to determine the filter bed maturity, and 5) weekly coliform measurement of the inflow/outflow to the filters to determine the filter removal rates.

Phase IV. Evaluation. The pilot plant performance were evaluated base on the results of Phase III. The criteria for evaluating pilot plant performance were based on criteria such as:

1. The ability of the plant to remove coliform bacteria: We are seeking removal of at least 90 to 99% of coliform bacteria.
2. The ability to reduce the turbidity of feed waters to an acceptable level.
3. Fairly long filter run times.

The difference in performance of each filter's materials were carefully evaluated. A final set of design recommendations and criteria for the actual slow sand filter were developed from the pilot plant data.

Principal Findings and Significance:
The results of the first phase of the slow sand filtration pilot study for Kosrae that was completed last year showed that the bacteria and turbidity removal rate for local basalt media was the same as the commercial sand media. However, the locally manufactured sand media had a longer initial run compared to off island media before being scraped. This was due to a large uniformity coefficient of the local sand media (4.5) compare to commercial sand media (2.2). Another problem we encountered last year was lack of a system to regulate inflow to the filters.

The monitoring and testing of the pilot plant performance has been completed. The preliminary results indicate that in order to increase the time between the filter's scraping, a settling tank is required. The actual size of the settling tank will depend on the time required for the solid particles to settle. The results will be carefully evaluated to determine the optimum uniformity coefficient for local media. There is great interest in applying SSF technology to other islands in the FSM. This is especially true on Pohnpei Island where a recent cholera outbreak is being blamed partially on unsanitary conditions in rural surface water supplies.